Ontario Hydro

RESEARCH DIVISION

91602
new 82-10

ontario hydro
research division
COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

TRITIUM STORAGE AND DELIVERY SYSTEM FOR ONTARIO HYDRO RESEARCH DIVISION TRITIUM LABORATORY

Report 86-164-K

W.T. Shmayda
Scientist-Metallurgical
Corrosion & Tritium Technology Section
Metallurgical Research Department

ABSTRACT

This report provides an overview of the Tritium Storage and Delivery System (TSDS) proposed for the tritium laboratory. A loop configuration is presented. For that arrangement, a performance and safety analysis is carried out. Equipment needed in the loop is identified. Typical fault scenarios and their consequence are described.

job	file	date	report no.
740682-530-050	827.28	April 22, 1987	86-164-K

91602
new 82-10

ontario hydro
research division

EXECUTIVE SUMMARY

TRITIUM STORAGE AND DELIVERY SYSTEM FOR THE TRITIUM LABORATORY

W.T. Shmayda
Corrosion and Tritium Technology Section
Metallurgical Research Department

Efforts are underway at Ontario Hydro Research Division to build a tritium laboratory with a working inventory of 5000 Curies. This laboratory will have three objectives:

- to carry out R&D in support of the CANDU reactor, in particular, the Tritium Removal Facility (TRF) currently under construction at Darlington GS.
- to provide a test facility to deal with unexpected tritium related problems that will arise after the commissioning of the TRF, and
- to carry out longer term R&D work in the field of tritium technology with applications aimed at both fission and fusion.

This report describes a Tritium Storage and Delivery System (TSDS) for the proposed tritium laboratory. A loop configuration is proposed. For that arrangement, a performance and safety analysis is carried out. Specific equipment needed in the loop is identified. Typical fault scenarios and their consequence are discussed.

job	file	date	report no.
740682-530-050	827.28	April 22, 1987	86-164-K

TABLE OF CONTENTS

		Page
1.0	FUNCTION AND DESIGN REQUIREMENTS	1
1.1	Functions	1
1.2	Design Requirements	1
1.3	Process Requirements	2
1.4	Structural Requirements	3
1.5	Maintenance	3
1.6	Instrumentation and Control	3
1.7	Interface Systems	4
1.8	Codes and Standards	4
2.0	DESIGN DESCRIPTION	4
2.1	System Description	4
2.1.1	Process Description	4
2.2	System Performance Characteristics	5
2.3	System Arrangement	6
2.4	Component Design Description	6
2.4.1	Transfer Container	6
2.4.2	Uranium Bed	6
2.4.3	Assay Volume	7
2.4.4	Inert Atmosphere Glove Box	7
2.4.5	Tritium Transfer Pumps	7
2.4.6	System Vacuum Pumps	8
2.4.7	Foreline Getter Trap	8
2.4.8	Gas Analysis Station	8
2.4.9	Pressure Monitors	8
2.4.10	Vacuum Monitors	8
2.4.11	Foreline Monitor	9
2.5	Instrumentation and Control	9
2.5.1	Temperature Instrumentation	9
2.5.2	Pressure Instrumentation	10
2.5.3	Radiation Monitoring Instrumentation	10
3.0	OPERATION	11
3.1	Initial System Preparation	11
3.2	System Operation	11

TABLE OF CONTENTS (Cont'd)

	Page
3.2.1 Tritium Storage	11
3.2.2 Tritium Delivery	12
3.2.3 Tritium Purification	12
4.0 CASUALTY EVENTS AND RECOVERY PROCEDURES	12
5.0 MAINTENANCE	12
5.1 General	12
5.2 Corrective Maintenance	13
5.3 Prevent Maintenance	13
6.0 MONITORING SYSTEM	13
6.1 Local Monitoring	13
6.2 Remote Monitoring/Control	14
6.3 Remote Monitoring Process and Control Displays	14
7.0 TSDS SYSTEM INTERFACE REQUIREMENTS	14
Distribution	Last Page

LIST OF FIGURES

Figure 1 - TSDS Flow Loop

Figure 2 - TSDS Placement in Tritium Laboratory

Figure 3 - TSDS Process Instrumentation

Figure 4 - Analysis Station and Pump Out System

LIST OF TABLES

Table 1 - Instrumentation and Control Requirements of TSDS

Table 2 - TSDS Failure Mode and Analysis

ontario hydro
research division

To Dr. D. Mills
Director of Research

TRITIUM STORAGE AND DELIVERY SYSTEM
FOR THE TRITIUM LABORATORY

1.0 FUNCTION AND DESIGN REQUIREMENTS

1.1 Functions

The functions of the Tritium Storage and Delivery System (TSDS) are to provide the following services to the tritium facility at Ontario Hydro Research:

1) Receive and store tritium,

2) Purify and maintain the purity of the stored tritium,

3) Regenerate and deliver to experimental vessels, measured aliquots of tritium, and

4) Keep tritium releases as low as is reasonably achievable.

1.2 Design Requirements

The Tritium Storage and Delivery System shall be designed in accordance with the following requirements:

1) Storage of tritium on-site

   - store as uranium tritide in a double walled container,

   - limit the on-site in-system tritium to 3000 Ci and the total on-site tritium inventory to 5000 Ci,

2) Recycle as much of the tritium supply as possible,

3) Minimize the deliberate conversion of tritium to oxide,

4) Supply of measured quantities of tritium

   - to deliver automatically a maximum of 600 Ci and a minimum of 1 Ci to the experimental vessels with an accuracy of $\pm$25 mCi

5) Evacuate experimentalists' vessels to 10^{-6} torr or better

   - confirm the leak tightness of each vessel to 10^{-8} torrliters/s Helium prior to tritium filling,

6) Control tritium purity

   - provide a means for removal of the Helium -3 decay product,

7) Provide redundant paths between the critical components within the inert atmosphere glove box,

8) Remotely control temperature of the uranium beds (U-beds),

9) Provide a temperature monitor for the calibrated volume,

10) Provide means for determining tritium purity and concentration in the system,

11) Provide for automatic operation with provisions for overrides - the local overrides will be used for system preparation and testing, and

12) Provide for fail-safe shutdown of all critical parts of the system.

1.3 Process Requirements

The tritium storage and delivery system shall receive tritium gas from an external supplier or from the Ontario Hydro Tritium Removal Facility at Darlington on uranium beds or in gas bottles.

The maximum permissible vulnerable quantity of tritium permitted onsite is 1200 Ci. The design basis inventory capability of a single uranium bed is 5000 Ci. Two such beds in parallel will be provided. With exception to tritium loading/unloading operations, the gas will be stored on one bed as a metal tritide.

The uranium bed shall be a double-contained vessel. All components which can be in contact with the total tritium inventory will be housed in a secondary containment having an inert atmosphere to prevent uranium oxidation or nitriding. Standard vacuum practices will be implemented to prevent tritium leakage to the glove box.

1.4 Structural Requirements

The system will be designed to minimize leakage. Components will be welded where feasible. Ultra high vacuum couplings will be used where components may require removal from the system. Vibration isolation bellows will be used between moving components and the loop. The integrity of the system shall be tested to provide assurance that radiation exposure to operating personnel and the general public are maintained as low as is reasonably achievable.

Interconnecting tubing and major components in contact with tritium shall be fabricated of 316 stainless steel. All welds shall meet the requirement of the ASME pressure vessel code, section VIII. All welds will have a leak rate of less than 3×10^{-8} torr-litres/s.

1.5 Maintenance

Redundant system pathways with connections between critical components will provide increased flexibility and reliability. Double containment of the most critical components will reduce tritium surface contamination when access for repairs, adjustment and calibrations is required.

Where feasible, standardization will be used for parts, materials and equipment. Detailed procedures are being developed to ensure that all maintenance operations are performed in a safe manner.

Systems design shall provide the capability to test equipment and controls, to verify the operational readiness of the TSDS, and to maintain the equipment in operating condition. Maintenance of equipment housed in the system's glove box will be performed in a utility glove box located elsewhere within the tritium laboratory.

The geometry of the system facilitates periodic inspection readily.

1.6 Instrumentation and Control

Process control instrumentation must be provided to acquire data concerning key parameters in the TSDS.

All instrumentation will provide signals for monitoring and control purposes. The instrumentation will be installed locally in the vicinity of the TSDS. All signals will be monitored remotely. Some will be displayed locally.

Displays and controls are required for the following parameters: temperature, pressure, activity, and selected valves which govern the system operations. Pictorial displays and activated sequences will be utilized to minimize operator error and to ensure that operating limits are not exceeded. Emergency power shall be available to all key components within the TSDS as well as its instrumentation and control subsystem 10 sec after a power failure.

1.7 Interface Systems

The TSDS requires outside services such as: electrical power, noninterruptible electrical power, and computer control. Interfaces with other systems include:

a) tritium lab inert atmosphere supply,
b) power distribution system, and
c) tritium cleanup system.

1.8 Codes and Standards

The TSDS is classified as a critical system and shall be built according to construction guidelines developed at Ontario Hydro Research for gaseous tritium services.

All welding shall be performed in accordance with the ASME pressure and vessel code Section VIII. Dye penetrant and/or helium leak tests shall be carried out on all welds.

2.0 DESIGN DESCRIPTION

2.1 System Description

2.1.1 Process Description

A conceptual layout of the TSDS is presented in Figure 1. The loop consists of a transfer pump, a uranium storage bed (USB) and an assay volume. A vacuum system necessary to evacuate the loop is not shown. The system receives, converts, stores and delivers to experimentalists' vessels tritium that is supplied by external sources or by the Ontario Hydro Tritium Removal Facility. The tritium supply container is attached to the system at port A, unloaded into the assay volume and quantified by the pressure-volume-temperature (PVT) method. The isotopic purity is verified by residual gas analysis. Subsequently, the tritium is loaded on the uranium storage bed. In this bed, the tritium is converted and stored as a uranium tritide.

Controlled external heating of the bed causes dissocation of the tritide thereby regenerating tritium gas. The quantity of gas regenerated is controlled through regulation of the tritide temperature and the duration of the pumping time. The tritium gas which has been transfered into the assay volume is subsequently introduced into the experimenter's vessel by volume expansion. The quantity of gas charged into the experimenter's vessel is determined by the volume ratio of the two volumes and by the starting tritium pressure in the assay volume. The experimentalist's vessel is isolated from the loop by the valve located at the vessel. Any gas remaining in the assay volume and in the line interconnecting the holding and experimentalist's vessel is returned to the USB before the valve isolating the storage system and the vessel can be closed and the experimentalist's vessel can be removed from the loop.

If tritium is held in a uranium bed for an extended period of time, the bed must be purged of He-3. To this end, the tritium is transferred to a standby bed. Helium is not gettered by the USB but must be evacuated after the new tritide has formed. Other impurities, such as oxygen, nitrogen, and carbon are eliminated automatically by the gettering action of the uranium. These impurities form stable compounds with uranium and have negligible dissociation pressures at typical USB operating temperatures. After tritium transfer and He-3 removal, the standby bed is used to supply tritium to the assay volume.

2.2 System Performance Characteristics

The TSDS shall meet the following performance conditions:

1) Provide for receiving tritium gas in shipping containers,

2) Provide for assaying and purity checking a new shipment of tritium gas by PVT analysis and residual gas analysis respectively,

3) Provide for transferring the tritium supply to storage beds where it is converted to solid uranium tritide until used, and

4) Provide for purifying and delivering measured amounts of tritium to the experimentalist's vessel in a reproducible manner.

In order to have sufficient capability and not limit operation of the tritium laboratory, equipment in the system which requires frequent maintenance or which is critical to normal operation has redundant components. One spare transfer pump and USB will be stocked in the tritium laboratory.

2.3 System Arrangement

Figure 2 shows the general location of the TSDS within the tritium laboratory. Figures 3 and 4 detail the process loop. All the equipment in the process loop that is exposed to tritium is located in an inert atmosphere glovebox inside the tritium laboratory. This permits system operation, inspection and maintenance while limiting personnel exposure. TSDS critical components shall be supported on a uni-strut structure to minimize tubing and pipe stresses at the coupling joints. Most components of the system will gradually become radioactive as they absorb tritium. For maintenance and adjustment purposes, all components shall be evacuated, purged, cleaned, and handled with gloves provided in the glove ports.

2.4 Component Design Description

2.4.1 Transfer Containers

Quantity and Size	1 at 25 cc and 1 at 75 cc
Material of Construction	Austenitic Stainless Steel
Design Pressure	1.5 bar
Design Temperature	400°C

The transfer containers are used to transport tritium from the TSDS to the work stations within the lab. They consist of a single walled stainless steel tank with a bellows sealed valve mounted directly on the end. The arrow scribed on the valve must point away from the tank. This valve orientation minimizes the chance of tritium loss due to valve failure.

2.4.2 Uranium Bed

Quantity	2 plus one spare
Size	1 litre
Material of Construction	
a) Outer Liner	Austenitic SS
b) Inner Liner	Austenitic SS
c) Powder Holders	OFHC copper
Design Pressure	10 bar
Design Temperature	500 °C
Operating Pressure	10^{-8} - 1013 millibar
Operating Temperature	20 - 425 °C
Heaters,	250 watts/120 volts

2.4.3 Assay Volume

Quantity	1
Size	10 cc
Material of Construction	Austenitic SS
Design Pressure	7 bar
Design Temperature	250 °C
Operating Pressure	10^{-8} - 1013 millibar
Operating Temperature	25 - 40 °C

The holding volumes are used to hold the tritium gas pumped from the uranium bed. The gas from this volume is used to fill the experimentalist's vessels.

2.4.4 Inert Atmosphere Glove Box

Material	11 Gauge, Type 304 Austenitic SS
Volume	1.5 m^3
Windows	1/2" Thick Safety Glass
Pass-through	15" Dia x 24" Long Airlock
Gloves	Butyl Rubber
Services	Electricity, Argon, Stack Exhaust

This glove box contains the components of the TSDS. The glove box serves as a secondary containment containing an inert atmosphere of argon. The argon is circulated through the Glove Box Cleanup System that removes any oxygen, water vapour that entered the glove box and any tritium that may have escaped from the loop.

2.4.5 Tritium Transfer Pump

Quantity	1 Normetex Scroll Pump
Material (Principal)	Austenitic SS
Pumping Rate	4 litres/s (at peak)

The tritium transfer pump shall operate in three modes:

(1) To transfer tritium from the tritium shipping container to the USBs.

(2) To circulate tritium and to transfer it between USBs and other system components.

(3) To transfer tritium directly from the USB to assay volume.

2.4.6 System Vacuum Pumps

Quantity	1 turbomolecular/rotary pump set
Type	
a) Rotary vane,	- helium tight forepump
b) Turbomolecular pump	- Tritium compatible - TPU100 or equal

The system vacuum pumps are used to clean out residual tritium and to pump down the system for testing and maintenance.

2.4.7 Foreline Getter Trap

Quantity	1 kg, ST198

2.4.8 Gas Analysis Station

Type	radio frequency mass spectrometer
Range	1 - 200 amu
Detector	Dual: Faraday cup and channeltron

Gas will be fed to the quadrupole analysis section by capillary lines or by molecular leak.

2.4.9 Pressure Monitors

a)	Type	Moderate Accuracy Capacitance Manometers
	Quantity	5 heads
	Range	0 - 1000 torr
	Accuracy	1%
b)	Type	High Accuracy Capacitance Manometers
	Quantity	2 heads
	Range	1 at 0 - 10 torr 1 at 0 - 1000 torr
	Accuracy	0.1%

2.4.10 Vacuum Monitors

Type	Ionization Gauge
Quantity	1
Range	10^{-3} - 10^{-8} torr
Accuracy	10%

2.4.11 Foreline Monitor

Type	Capacitance Manometer Low accuracy
Quantity	1 head
Range	0 - 1000 torr
Accuracy	5%

2.5 Instrumentation and Control

The TSDS is designed to provide controlled quantities of pure tritium into the holding volume. This requires accurate measurement and control of pressure, temperature, and purity of the tritium. Instrumentation for monitoring critical operations shall be redundant.

Pressure and temperature are monitored both locally and remotely. All valves necessary for remote operation can be computer controlled.

Instrumentation and control equipment for this system are presented in Table 1. Also, the table gives a list of measured parameters, sensors used with their function (control or diagnostic), the type of display and the location.

2.5.1 Temperature Instrumentation

Temperature monitors are available at the following locations

a) Tritium Shipping Container - The temperature of the gas in the container shall be indicated locally and monitored and recorded in the data acquisition system.

b) Uranium Storage Beds - The temperature of USBs shall be monitored, controlled and recorded by the computer. Temperatures in excess of 450°C will activate a power cut-off and an alarm. Under normal conditions, the temperature will indicate the condition of a given bed and help to determine when adequate tritium has been generated. The idle bed used for storage should be kept at room temperature.

c) Assay Volume - This volume holds the tritium before transfer to the experimenter's vessel. Temperature is monitored and displayed locally, and recorded remotely.

d) Glove Box - The TSDS glove box serves as a secondary containment for the system. Temperature within this box will be monitored and alarmed remotely.

2.5.2 Pressure Instrumentation

Pressure monitors are available at the following locations:

a) Tritium Shipping Container - The pressure of the tritium in the container shall be monitored locally and recorded remotely.

b) Uranium Storage Beds - The pressure in the USB shall be monitored and displayed locally but recorded and controlled remotely. To reduce permeation rates, the pressure in the beds should be kept as low as possible when the vessels are hot.

c) Assay Volumes - Since the assay volume supplies the tritium to the transfer volume, it is important to know the pressure in the vessel accurately. The pressure is displayed locally but controlled and recorded remotely.

d) Pumps - Pressure gauges and where applicable vacuum monitors are provided on the inlet and outlet of each pump to show pump operation. These are displayed and recorded remotely only.

e) Glove Boxes - Pressure within the glove boxes shall be displayed locally and recorded remotely. To decrease impurity contamination of the glove box clean up system, the glove box shall be operated at 3 inches of water above atmospheric pressure.

2.5.3 Radiation Monitoring Instrumentation

Tritium activity shall be monitored in the glove box. A high alarm in the glove box indicates a malfunction in the operation of the glove box cleanup system or an accidental leakage of tritium into the box. Normally, an increasing activity trend will allow the operator to take corrective measures before significant tritium is found in the glove box. The tritium monitors are ionization chamber detectors which have a minimum detection level of 5 microcuries/m^3 for tritium. The activity is recorded remotely.

3.0 OPERATION

3.1 Initial System Preparation

The Tritium Storage and Delivery System will be built and fully tested at the Ontario Hydro Research laboratories. Each component of the system is to be inspected and cleaned prior to installation. Valves, pipes, tubing, and pumps in the system shall be checked for leakage using helium leak testing where-ever possible.

A high velocity purging of the system using helium gas shall be used to flush particulate material and other potential contamination from all lines in the system.

Instruments will be calibrated and checked for accuracy and response time throughout their span. Motors shall be checked for direction of rotation, and pumps for capacity and operating pressure.

All automatic controls shall be tested for activation at the proper set points. Alarm functions shall be checked for operability and proper set points. The TSDS shall be operated and tested both from the computer and the local control panel. The system will be checked with regard to flow paths, flow rates, and mechanical operability.

A series of pre-operational tests will be performed using hydrogen and/or deuterium. Experience gained during these tests will be directly applicable to subsequent tritium operations and will form the basis of operation and maintenance manuals.

3.2 System Operation

The system is contained inside a sealed glove box to provide maximum safety of operation. A glove box atmosphere cleanup system is provided to clean up any traces of accidentally or chronically released tritium.

The TSDS has three modes of operation as follows.

3.2.1 Tritium Storage

The operations necessary for storing tritium are locally controlled in the vicinity of the TSDS glove box. The tritium gas shipping container is placed in the box where the quantity of tritium is verified by the PVT method. The tritium determined shall be recorded for inventory purposes. Purity of the tritium is also checked by residual gas analysis before it

is transferred by pumping from the shipping container to the uranium bed where it is stored in the form of solid uranium tritide. The system has two storage beds, each capable of storing 5000 Curies of tritium.

After the tritium is transferred to the TSDS system, the shipping container is removed from the glove box. The cleanup system for the TSDS shall operate continuously.

3.2.2 Tritium Delivery

Operation in the tritium delivery mode is controlled remotely. The tritium is delivered to the transfer vessel in a single specified quantity. The tritium gas is generated by heating the storage bed to the required temperature. A pump will be used to transfer the gas from the bed to the assay volume to attain the required pressure. The volume of the transfer vessel and its leak tightness will be measured prior to the tritium charging operation.

3.2.3 Tritium Purification

The TSDS incorporates two uranium beds. One is used at any one time for storage and delivery operations. A third bed, which serves as a redundant critical component of the system, is stored externally to the TSDS glove box.

When tritium is stored as uranium tritide for a prolonged period of time (days), the bed must be purged, of He-3 before reuse. If a considerable amount of He-3 has built-up, the tritium will be transferred to the standby bed. Helium does not react with the uranium and will be evacuated from the loop via the vacuum system after the transfer operation. Circulation over the cold bed with the transfer pump may be necessary to encourage the tritiding reaction.

4.0 CASUALTY EVENTS AND RECOVERY PROCEDURES

Table 2 gives failure mode and effects analysis for the tritium storage and delivery system. At least one failure is postulated for each major component of the TSDS. Additionally, various line breaks throughout the system are also considered. In each case, the possibility of such a failure as well as the local effects, detection methods, and corrective provisions is considered.

5.0 MAINTENANCE

5.1 General

The TSDS will be in intermittent use throughout the T_2 lab operation. Periodic visual inspection and preventive

maintenance are conducted using normal industrial practice. Equipment is selected and arranged to allow operation, inspection, and maintenance.

5.2 Corrective Maintenance

Corrective maintenance is accomplished in stages. Preparation is accomplished by isolating the components, monitoring the radiation while purging it, observing industrial safety procedures, and venting and/or draining the equipment. The required maintenance is then performed followed by rechecking all hardware work for correct installation and connection procedures. A log book of the equipment repairs and the sequence of work undertaken is to be kept.

5.3 Prevent Maintenance

Preventive maintenance which is performed on a specified periodic inspection schedule, includes inspection and replacement as required of seals, fittings, filters, thermocouples, switchs and apparatus. Preventive maintenance is also performed during visual or indicated equipment malfunction during system operation.

As part of normal system operation, tests, inspections, data tabulation and instrument calibrations are made to evaluate the condition, and performance of the Tritium Storage and Delivery System equipment and instrumentation. Data will be taken periodically during normal system operation to confirm heat transfer capabilities and U-bed efficiency. Pump and valve leakage will be monitored for radiation.

6.0 MONITORING SYSTEM

The monitoring system is subdivided into two general types: local and remote. Components of each type are identified in Table 1.

6.1 Local Monitoring

The monitoring method uses rack mounted controllers with built-in displays. Where the option is available digital readouts are preferable. These controllers are located in the general vicinity of the TSDS and are intended for continuous monitor and display the status quo of peripheral equipment and in some cases for the control of this equipment.

6.2 Remote Monitoring/Control

This monitoring method uses a computer driven data acquisition system and does not display directly the status of any component although such monitoring can be called up on the CRT if required. The purpose of this monitoring is:

a) To record on a continuous basis the status of various TSDS components for future reference.

b) To alarm abnormal conditions. Some of the temperature monitors used in this mode are shared with the local monitoring system.

c) To control processes.

6.3 Remote Monitoring Process and Control Displays

Two displays are used for the remote monitoring/control system: an alarm panel and a process panel.

The alarm panel consists of a pictorial representation of the overall TSDS system. Abnormal conditions are indicated on the loop with strategically placed lights (LEDs). The specific fault conditions are described on the CRT and the response options are presented to the operator.

The process panel consists of a pictorial representation of the TSDS process loop. Software to automatically carry out specific operations is installed in the computer and is used to guide the operator through the various processes via a keyboard.

Progress through the operation is indicated on the process loop via lights.

Three automatic operations are to be installed initially

a) Charging the experimenter's vessel,

b) Helium-3 separation from T_2, and

c) Automated shut down for some off-normal conditions.

7.0 TSDS SYSTEM INTERFACE REQUIREMENTS

The TSDS system interface requirements are:

a) Tritium Laboratory

This facility shall provide space and common services for the TSDS. Instrument air shall be provided for the

operation of pneumatic valves. This atmosphere shall be argon, supplied at 90 psig ±10 psig at full flow, oil free and have only trace quantities of water vapour.

Area tritium monitors shall be placed at strategic locations within the lab to detect any abnormal leakage in the lab. Significant leakage shall be alarmed and crosschecked with leakage in the glove box. If positive, an automatic shutdown sequence will occur.

b) Power

During normal operation, power is supplied from the power grid. During a power outage, uninterruptible power shall be provided to the TSDS to maintain instrumentation and control functions so that a controlled shutdown into a safe mode can be executed.

c) The Glove Box Cleanup System

The TSDS shall have an independent dedicated glove box cleanup system based on getters. T_2 burning and subsequent sorption on molecular sieves has been avoided to reduce chronic exposure to operators.

d) Radioactive Waste Handling

The radioactive wastes generated during the operation of the TSDS shall be transferred to the waste handling work station for ultimate disposal.

Approved by:

James Brown

J. Brown
Manager
Metallurgical Research
Department

Prepared by:

W. Shmayda

W. Shmayda
Scientist
Corrosion and Tritium
Technology Section

Recommended by:

P.C. Lichtenberger

P.C. Lichtenberger
Supervising Scientist
Corrosion and Tritium
Technology Section

WS:mb/mao

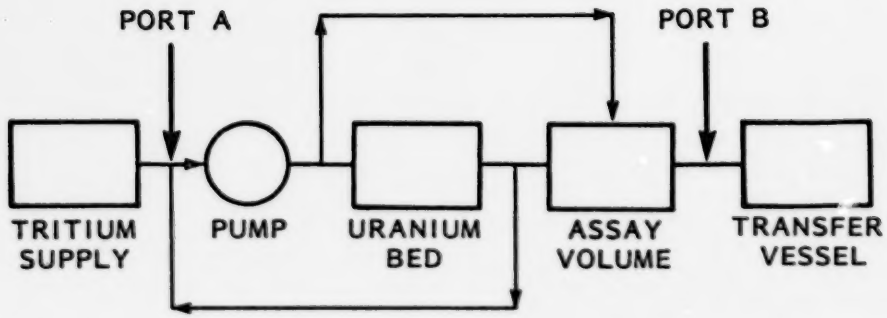
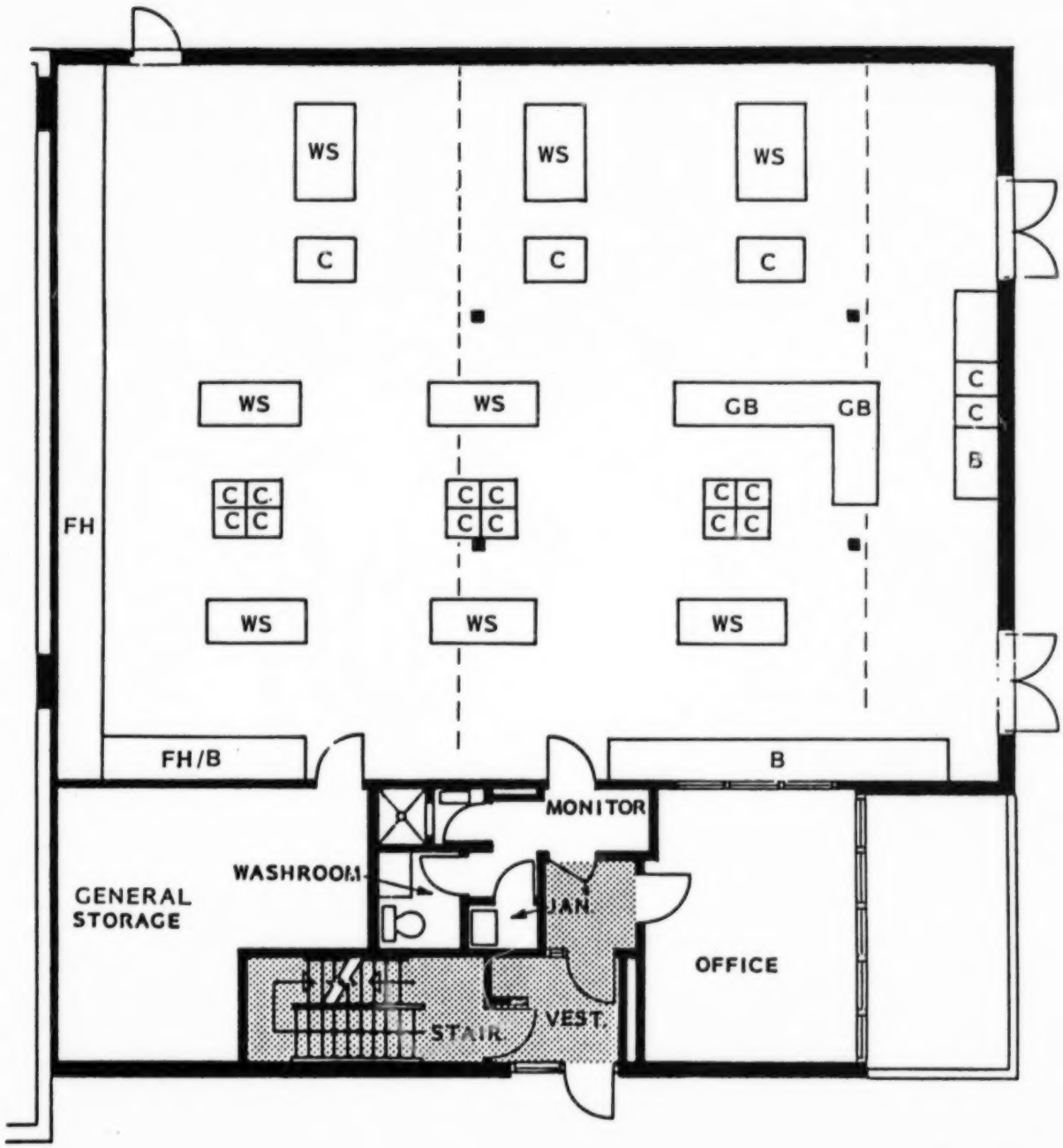


FIGURE 1 - TSDS FLOW LOOP



B - BENCH
C - CONTROL INSTRUMENTATION CABINET
FH - FUMEHOOD HOODS
WS - WORK STATION
GB - TSDS GLOVEBOX
■ - STRUCTURAL COLUMNS

FIGURE 2 - TSDS PLACEMENT IN TRITIUM LABORATORY

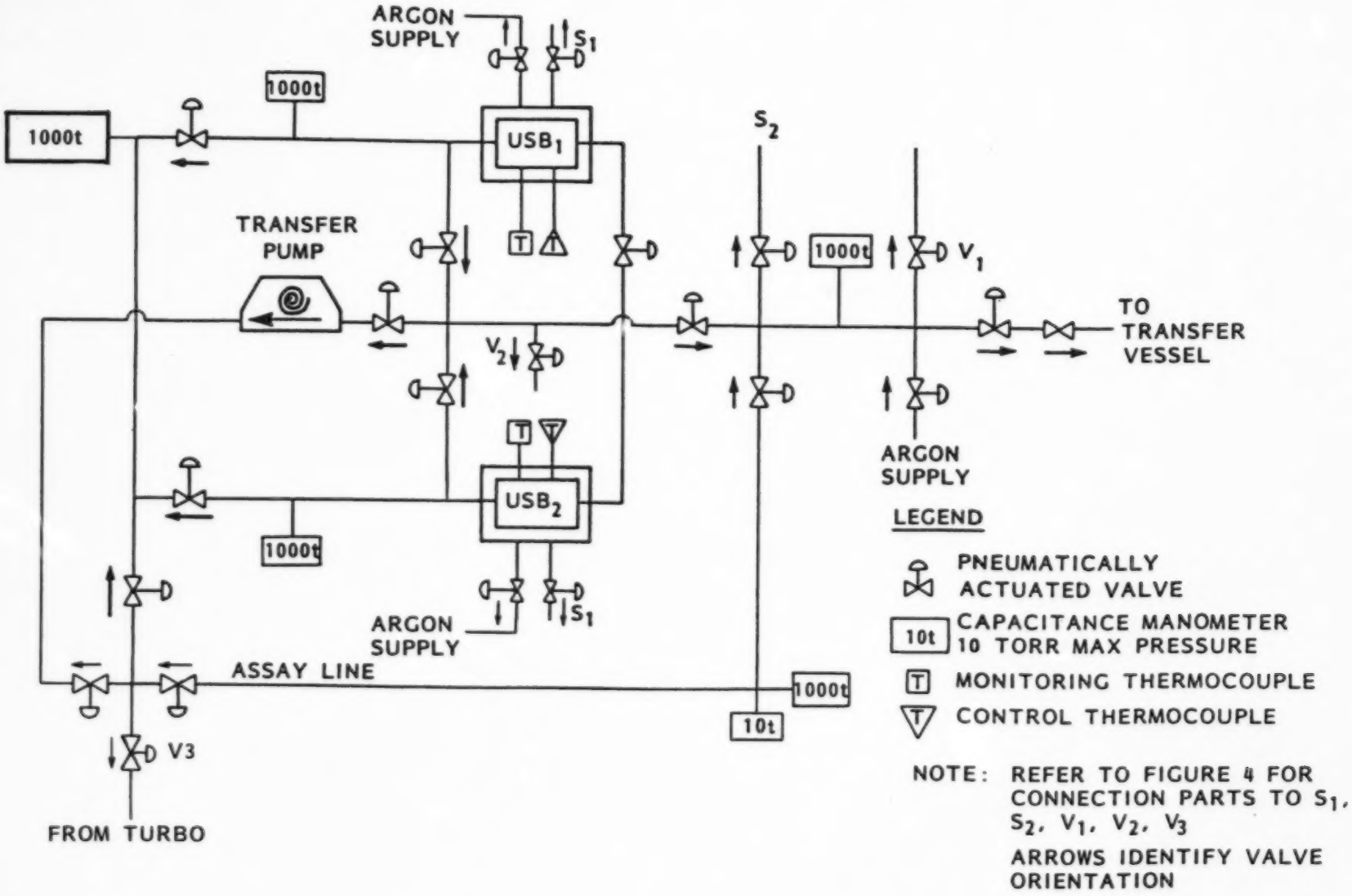


FIGURE 3 - TSDS PROCESS INSTRUMENTATION

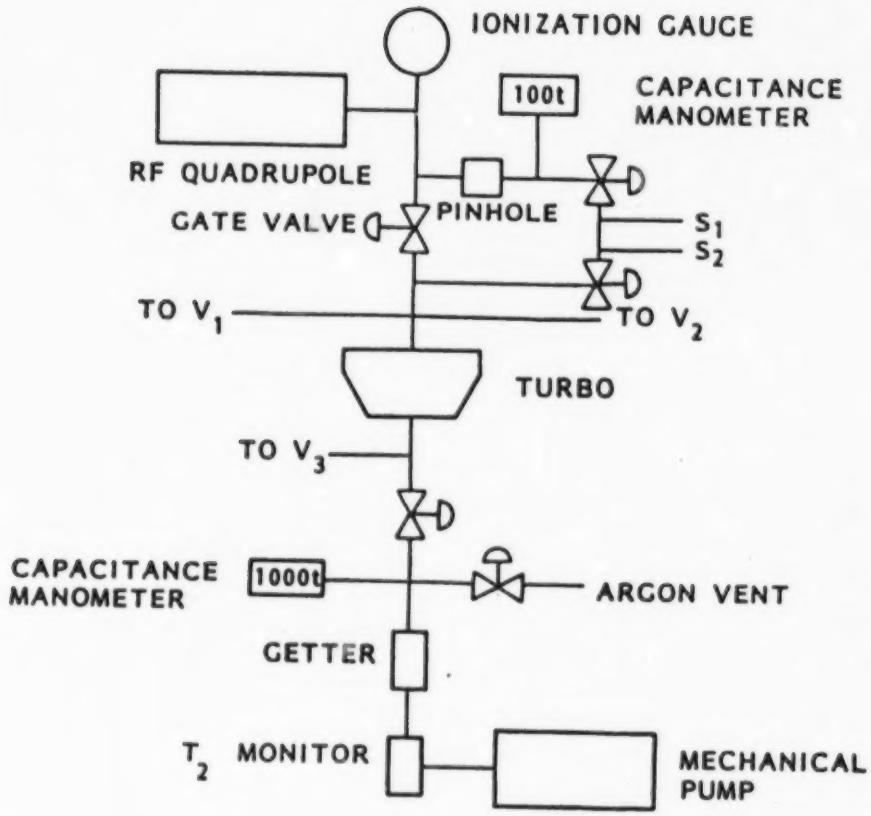


FIGURE 4 - ANALYTIC STATION AND PUMP OUT SYSTEM

TABLE 1

INSTRUMENTATION AND CONTROL REQUIREMENTS FOR TSDS

Qty	Parameter	Sensor		Signal		Readout Location		Function	
		Type	Range	Recording	Output	Local	Computer	Control	Diagnostic
1	Temperature of shipping container	thermocouple	0-500°C	X	alarm		X		X
1	Temperature of heater for shipping container	thermocouple	0-500°C		display	X		X	
2	Pump oil temperature	thermocouple	0-100°C	X	alarm		X	X	
	Temperature circulation pump	thermocouple	0-100°C	X	alarm		X	X	
2	Temperature of U-bed	thermocouple	0-500°C	X	alarm		X	X	
2	Temperature of U-bed heaters	thermocouple	0-500°C		display	X		X	
1	Getter bed temperature	thermocouple	0-50°C		alarm	X		X	
1	Tritium purity level	RF Quad				X	X		X
1	Temperature of glovebox	thermocouple	0-50°C	X	alarm		X		X
1	Glove box pressure	capacitance manometer	0 ± 8 cm H_2O	X	display/ alarm	X			X
1	Argon supply pressure	capacitance manometer	0-20 MPa		display	X			
1	Argon delivery pressure		0-100 kPa		display/ alarm	X			
1	Tritium pressure in shipping container	capacitance manometer	0-100 kPa	X	display	X	X		X
1	Pump (circ) delivery pressure	capacitance manometer	0-100 kPa		alarm	X			X
1	Foreline pressure	capacitance manometer	0-100 kPa	X	display	X	X	X	
1	Sample system	capacitance manometer	0-10 kPa	X	display		X		X
2	U-bed pressure	capacitance manometer	0.1-100 kPa	X	display/ alarm	X	X	X	
1	Assay volume pressure	capacitance manometer	0.01-100 kPa	X	display	X	X		X
1	System Vacuum	ionization gauge	10^{-8}-10^{-3} mb		display	X	X	X	
1	Exhaust Process Line Activity	ionization gauge	0.1-100mCi/m^3	X	alarm		X	X	
1	Glove box tritium activity level	ionization gauge	$10-10^4$ μCi/m^3	X	alarm	X	X	X	
1	Air in leakage detection	O_2 analyzer			alarm display	X			
1	Air in leakage detection	H_2O vapour monitor			alarm/ display	X			

TABLE 2

TSDS FAILURE MODE & ANALYSIS

Component	Failure Mode	Cause	Effect	Detection Method	Corrective Action
Shipping Container	leakage/rupture	valve, line breakage	T_2 release into glovebox	T_2 monitor alarm	- cool shipping container to room temperature - clean the glove box atmosphere using the box's clean-up system
T_2 line inside glovebox	leakage/rupture	faulty weld, valve breakage	T_2 release into glove box or argon ingress into line	T_2 monitor alarm or vacuum gauge/ pressure gauge alarm	- return remaining T_2 to cold bed - cool active bed - clean glove box atmosphere with box's cleanup system
Transfer Pump	failure to operate	electrical/ mechanical malfunction	loss of head pressure loss of flow	discharge pressure sensor	- return T to U-bed - flush pump with argon - replace with spare
U-bed	leakage/rupture	over pressurized a valved off bed, faulty weld	T_2 release into secondary container	T_2 monitor alarm in foreline	- maintain bed under vacuum - transfer T_2 to cold bed - backfill faulty bed with argon - replace with spare
Holding Volume	leakage/rupture	faulty weld, valve or transducer fitting	loss of vacuum in loop	pressure gauge T_2 monitor alarm in foreline	- transfer remaining T_2 to cold U-bed - backfill volume with argon - replace
Glove box	argon outleakage or air inleakage	- over pressurized supply gas line - glove port failure	- argon release into T_2 lab - ingress of O_2 and H_2O vapour into box	- box pressure sensor - O_2 and H_2O detectors	- return any T_2 to U-bed - turn-off electrical power to beds - vent valve actuator manifold - reduce supply pressure - rebag glove port
Pump Temperature Excessive	pump siezed or stops working	motor or pump overheated	- pressure build-up in heated Ubed - excessive T_2 losses to secondary containment	- pump temperature sensor - discharge pressure sensor - U-bed pressure sensor	- transfer T_2 to cold bed - flush pump with argon - replace with spare

DISTRIBUTION

Dr. D. Mills	Director of Research
Mr. B. Davidson	Darlington NGS
Mr. S. Von Hatten	Darlington NGS
Mr. T.J. Carter	Design & Dev - Gen, H11G27
Mr. R. Kohout	Design & Dev - Gen, H11F18
Mr. J. Li	Design & Dev - Gen, H11E27
Dr. S. Sood	Desing & Dev - Gen, H11E27
Mrs. A.K. Macmillan	Darlington Projects, H16F1
Dr. T.S. Drolet	New Business Ventures, C27F01
Dr. D.P. Dautovich	Fusion Centre
Dr. K.Y. Wong	Fusion Centre
Mrs. C. Burnham	Fusion Centre
Mr. A. Meikle	Fusion Centre
Mr. R. Sparkes	Health & Safety Division - CHPS
Mr. J. Miller	Health & Safety Division - CHPS
Dr. M. Anyas-Weiss	Electrical Research
Dr. R. Glass	Chemical Research
Dr. D. Dodd	Chemical Research
Mrs. S. Vekris	Chemical Research
Dr. M. Booth	Chemical Research
Dr. G. Orgram	Chemical Research
Dr. F. Spencer	Chemical Research
Dr. O. Melo	Chemical Research
Dr. J. Brown	Metallurgical Research
Dr. P.C. Lichtenberger	Metallurgical Research
Mr. J.O. Noga	Metallurgical Research
Mr. A. Heics	Metallurgical Research
Mr. N.P. Kherani	Metallurgical Research
Mr. K.D. Geiger	Metallurgical Research
Mr. B.L. Fishbein	Metallurgical Research
Mr. R.A. Opatril	Metallurgical Research
Dr. W.T. Shmayda	Metallurgical Research

Public Reference Centre
Editorial Section (2)
Office Copies (3)
Extra Copies (3)